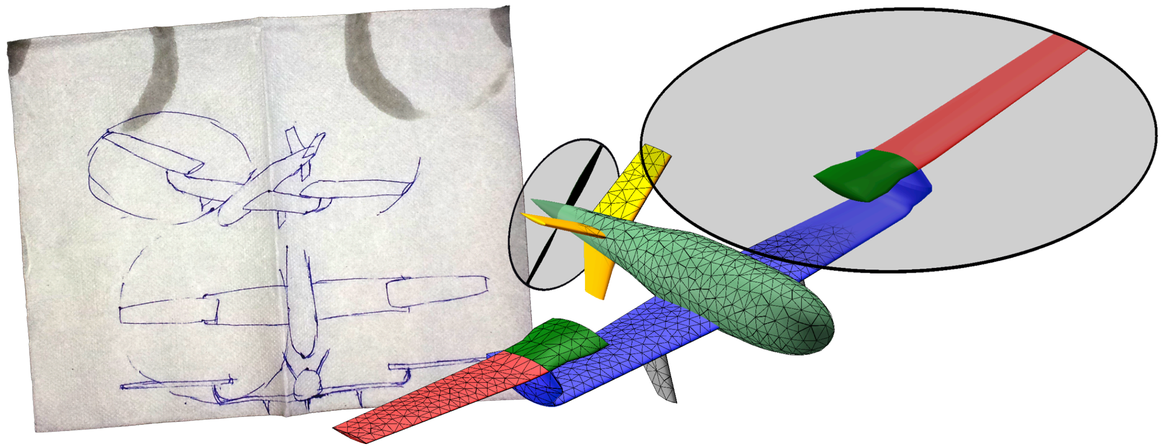


OpenVSP Workshop

Rob McDonald

NASA Ames
August 23-25, 2016

Geometry as Origin of Analysis (Design)

- Shape is fundamental starting point for physics-based analysis
  - Aerodynamics
  - Structures
  - Aeroelasticity
  - Aerothermal / Heating
  - Mass Properties
  - Acoustics
  - RCS / Signatures
  - Packaging / Layout
  - Manufacturing
  - etc.

- Across disciplines and fidelity, shape is the common denominator.

- Unfortunately, there is little to no commonality in practice.

What is Geometry?

What is a circle (sphere)?

What is Geometry?

What is a circle (sphere)?

- The locus of points equidistant from a given point (x_0, y_0, r).
- A circle is an idea.
- Many approximate representations exist.






What is Geometry?

What is a circle?

What is a parameter?

- A labeled quantity that is familiar to deal with:
  - Aspect Ratio
  - Taper Ratio
  - Thickness to Chord Ratio

- Some parameters are dimensions with special names.
  - Sweep Angle
  - Wing Span

- Familiar parameters correspond to *canonical* shapes.
  - Circle
  - Airfoil
  - Wing

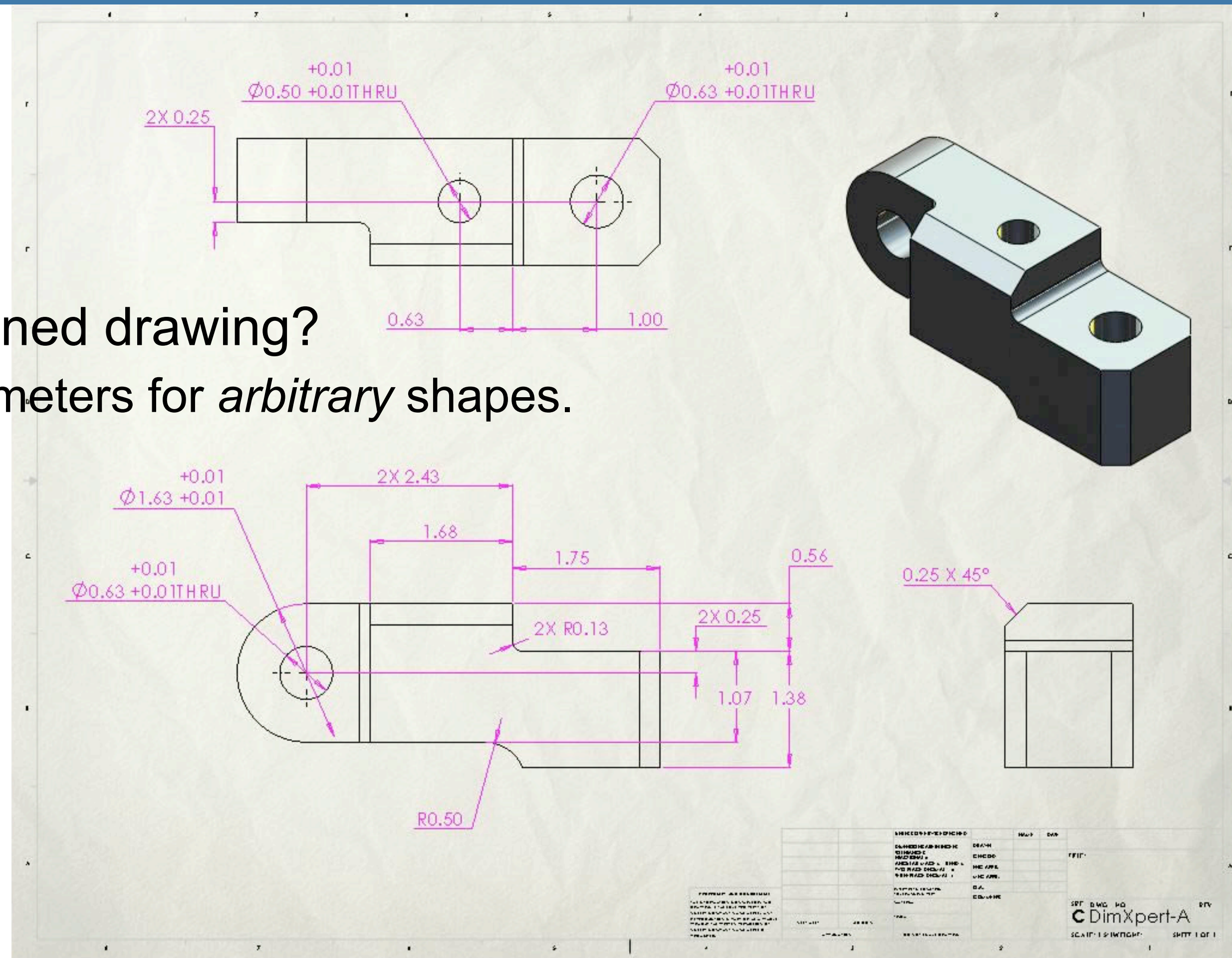
What is Geometry?

What is a circle?

What is a parameter?

Is geometry a dimensioned drawing?

- Dimensions are parameters for *arbitrary* shapes.



What is Geometry?

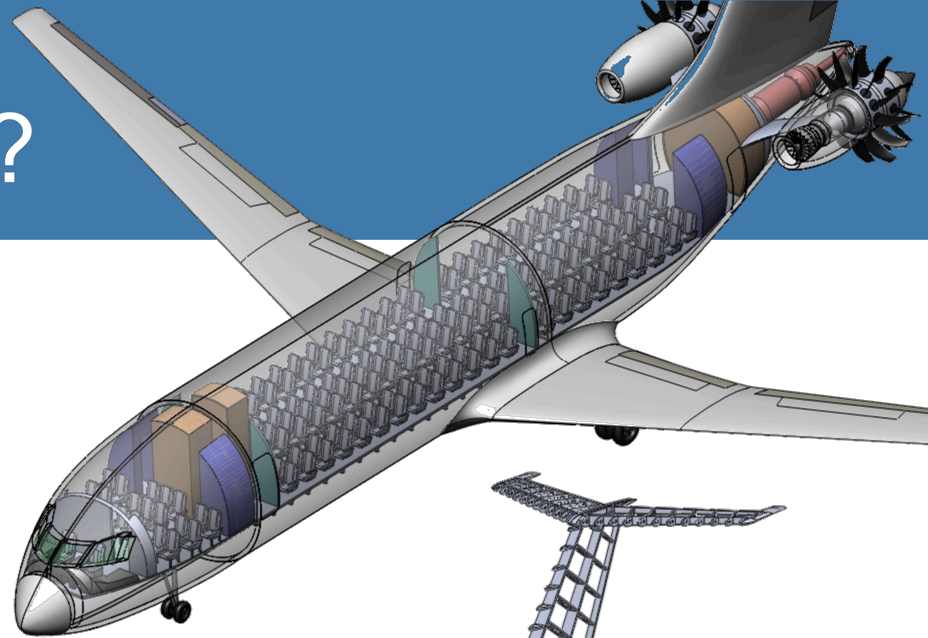
What is a circle?

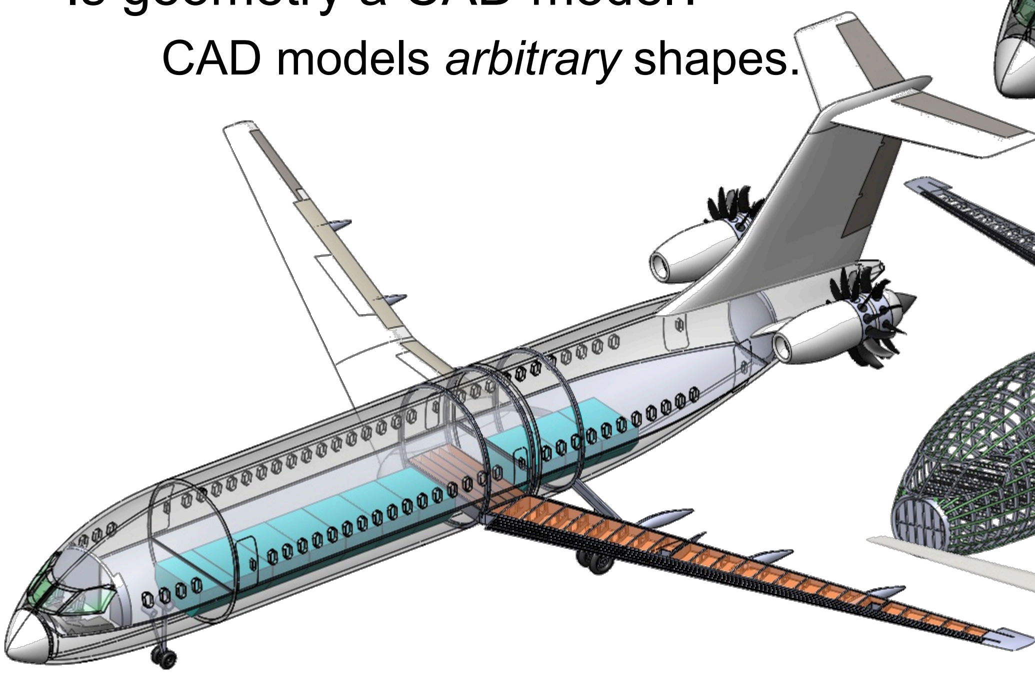
What is a parameter?

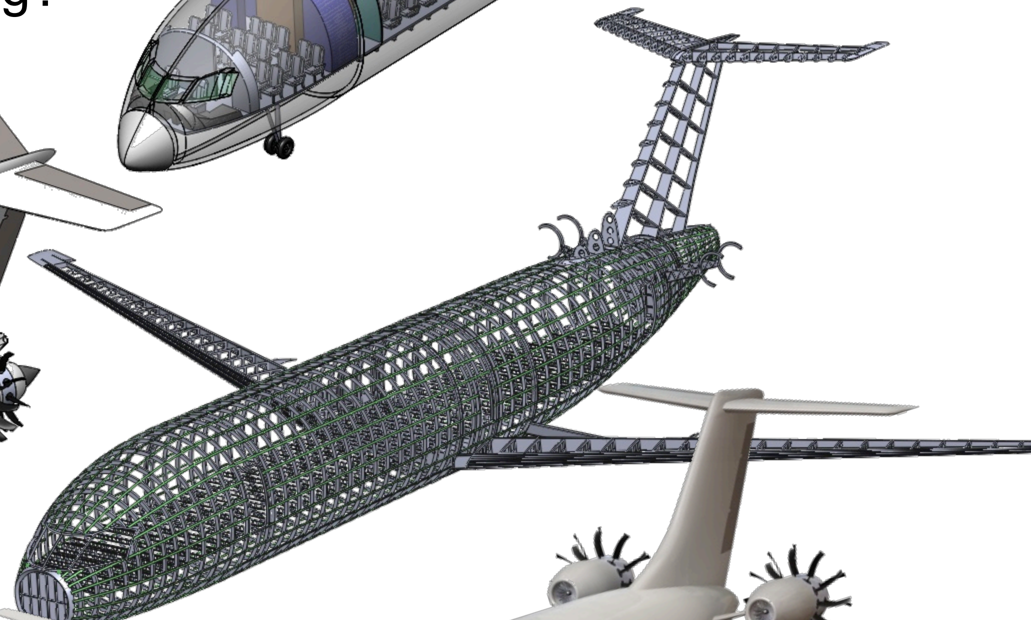
Is geometry a dimensioned drawing?

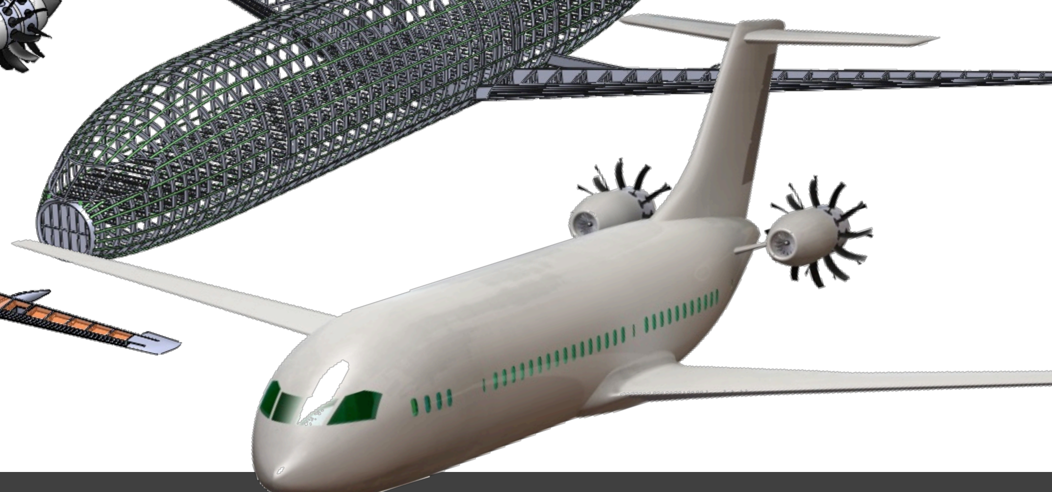
Is geometry a CAD model?

CAD models *arbitrary* shapes.









Geometry Modeling Gap

Three approaches have evolved to geometry modeling for physics-based analysis.

- Analysis Integrated
  - Each code generates geometry based on its own inputs.

Parametric Geometry

- CAD Based
  - General-purpose CAD is used to model geometry.
  - Prepared for analysis through grid generation and pre-processing tools.

Geometry (Mis)Representation

'True' geometry does not correspond to analysis representation.

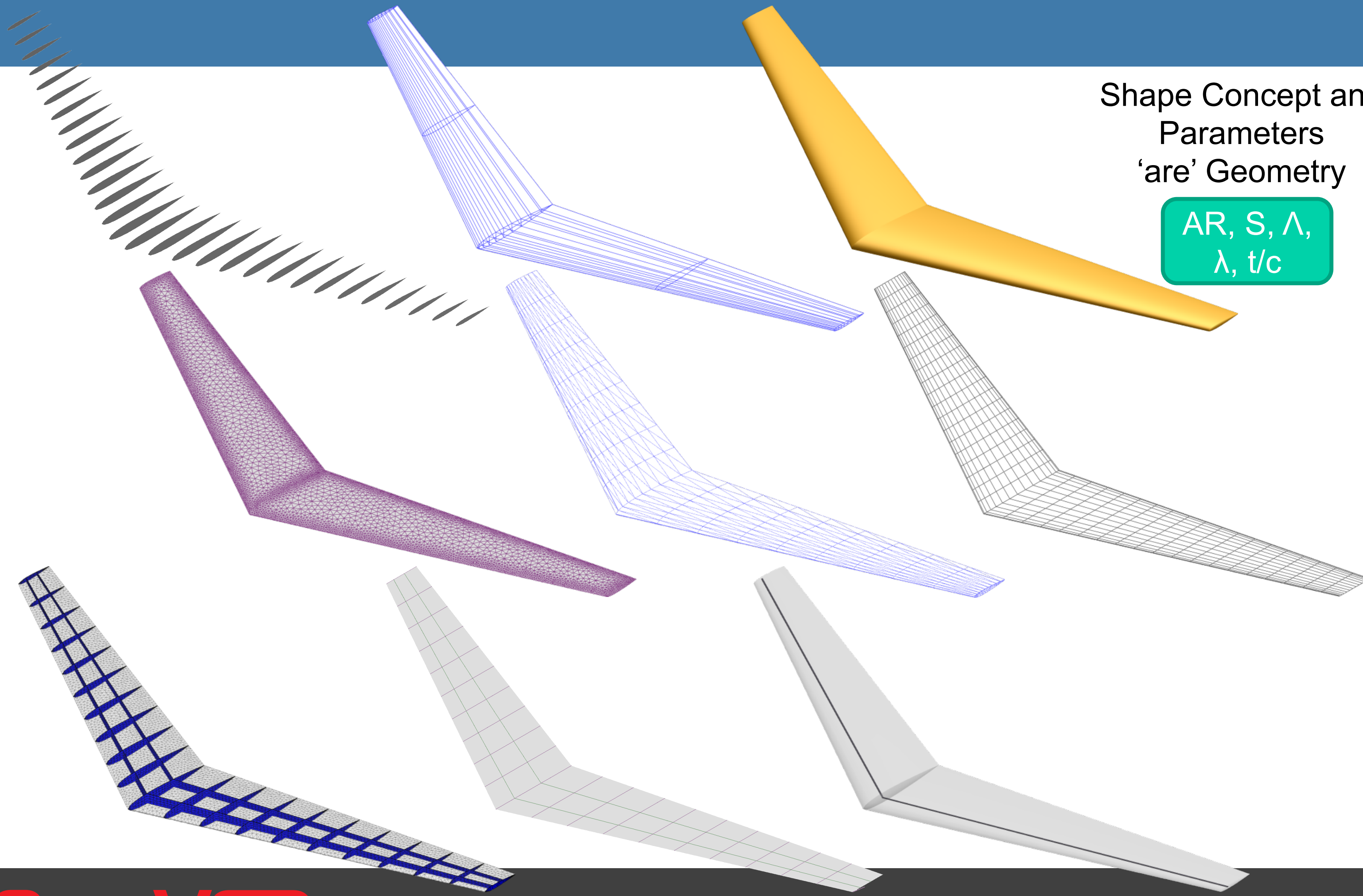
- CAD models can be built with varying (single) intent
  - Manufacturing
    - Represent manufacturing process, target CAM
  - Integration & Maintenance
    - Packaging, accessibility, etc.
  - Structures
    - Represent loads & load paths, target FEA
      - Many elements do not correspond to CAD model
        Beam, rod, shell, plate, etc.
  - Aerodynamics
    - Represent OML, propulsion, control surfaces

Analysis Fidelity Holes

Single model-to-analysis work flow typically developed.

- Fidelity selected (at least limited) by geometry model.
- Very little choice in analysis fidelity.
- Sparsely populated fidelity / discipline matrix.

Many Models Possible Representation of Geometry

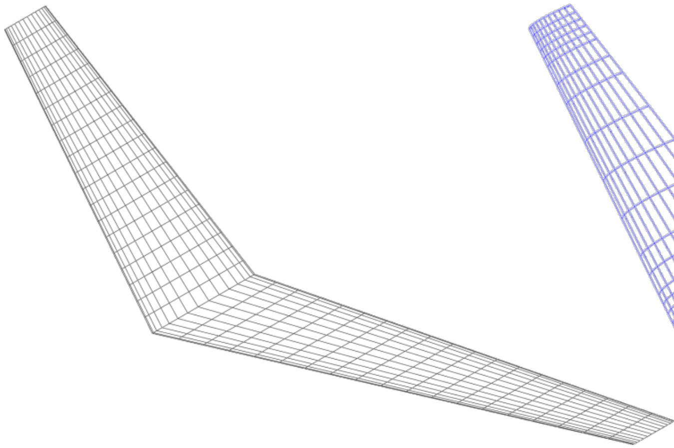


Shape Concept and Parameters ‘are’ Geometry

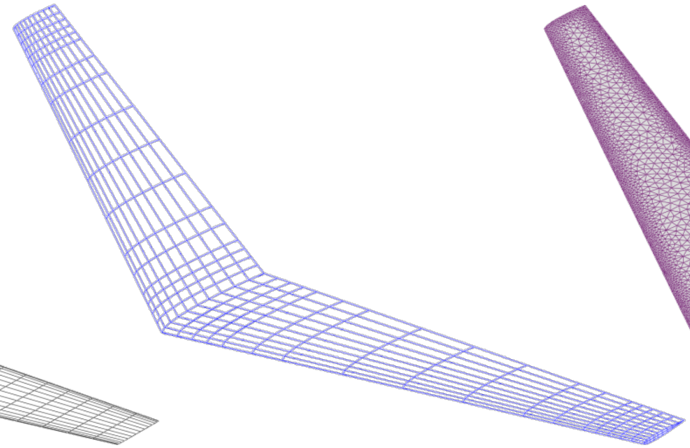
AR, S, Λ, λ, t/c

Representation Relates to Fidelity

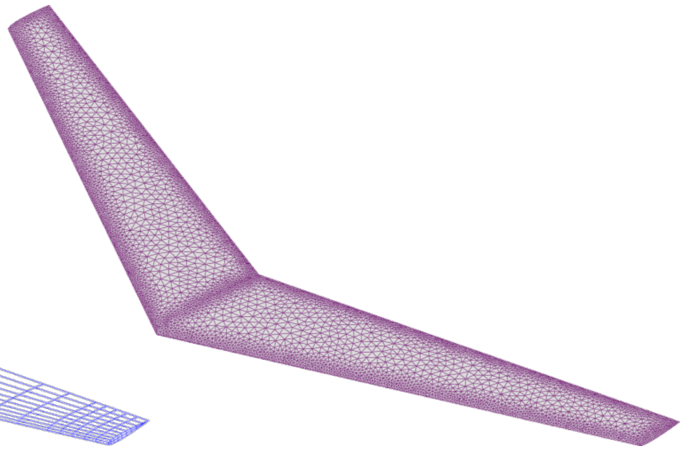
Vortex
Lattice



Panel
Code

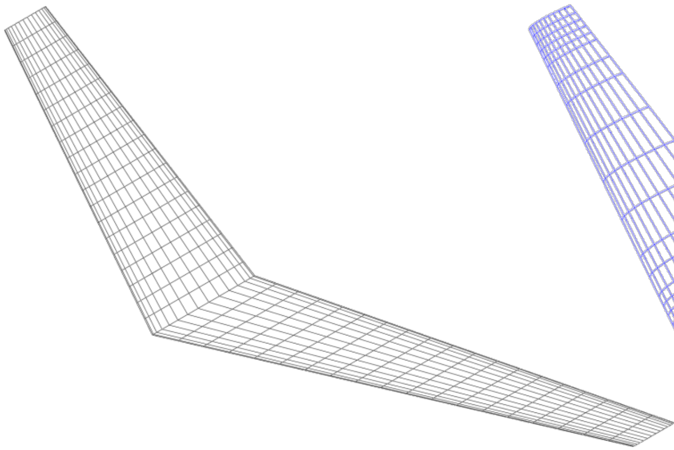


CFD

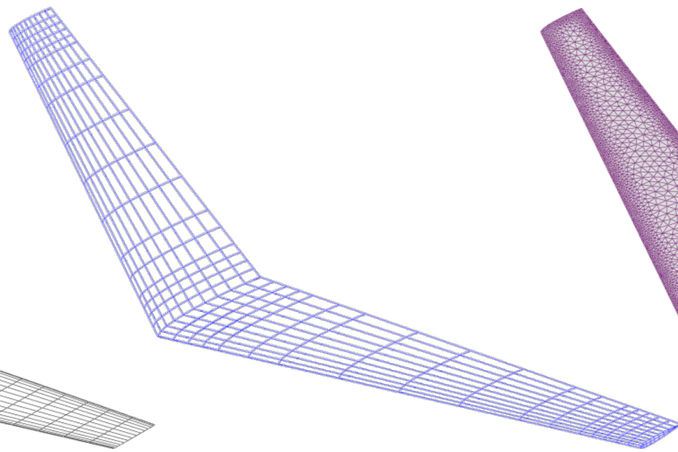


Often Mistaken for Design Stage

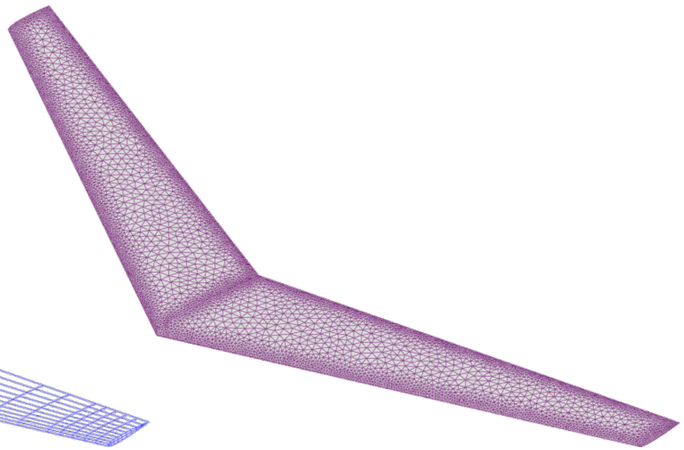
Vortex Lattice



Panel Code



CFD



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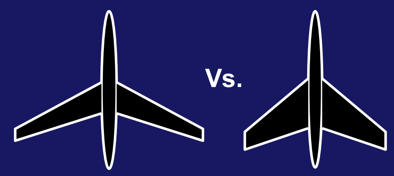
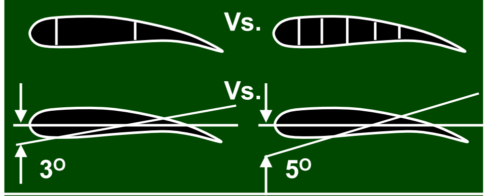
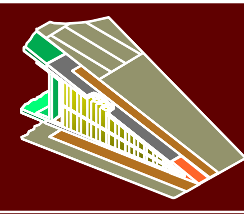
Conceptual | Preliminary | Detail

Phases of Aircraft Design

Design phase is about **<u>what</u>** decisions are being made, not **<u>how</u>** they are made.*

	Phase I Conceptual Design	Phase II Preliminary Design	Phase III Detail Design
			
Known	• Basic Mission Requirements • Range, Altitude, Speed • Basic Material Properties σ/ρ E/ρ $.lb	• Aeroelastic Requirements • Fatigue Requirements • Flutter Requirements • Overall Strength Requirements	• Local Strength Requirements • Producibility • Functional Requirements
Results	**Geometry:** Air Foil Type, R, t/c, λ, Δ **Design Objectives:** Drag Level, Weight Goals, Cost Goals	• Basic Internal Arrangement • Complete External Configuration – *Camber, Twist Distributions* – *Local Flow Problems Solved* • Major Loads, Stresses, Deflections	• Detail Design – *Mechanisms* – *Joints, Fittings & Attachments* • Design Refinements as Results of Test
Output	Feasible Design	Mature Design	Shop Drawings
TRL	2-3	4-5	6-7

Leland Nicolai, Fundamentals of Aircraft and Airship Design, AIAA, 2010.

*Except where certain decisions require more advanced techniques.

Parameters Evolve Through Design

Shape Concept and Parameters
'are' Geometry

True through **entire** design process.

Conceptual	Preliminary	Detail
AR, S, Λ, λ, t/c	twist = f(η), t/c = f(η), Complex Planform, High-lift geometry, Control surfaces	Detailed part designs
General Concept	High-Level Finesse	Every Aspect Determined

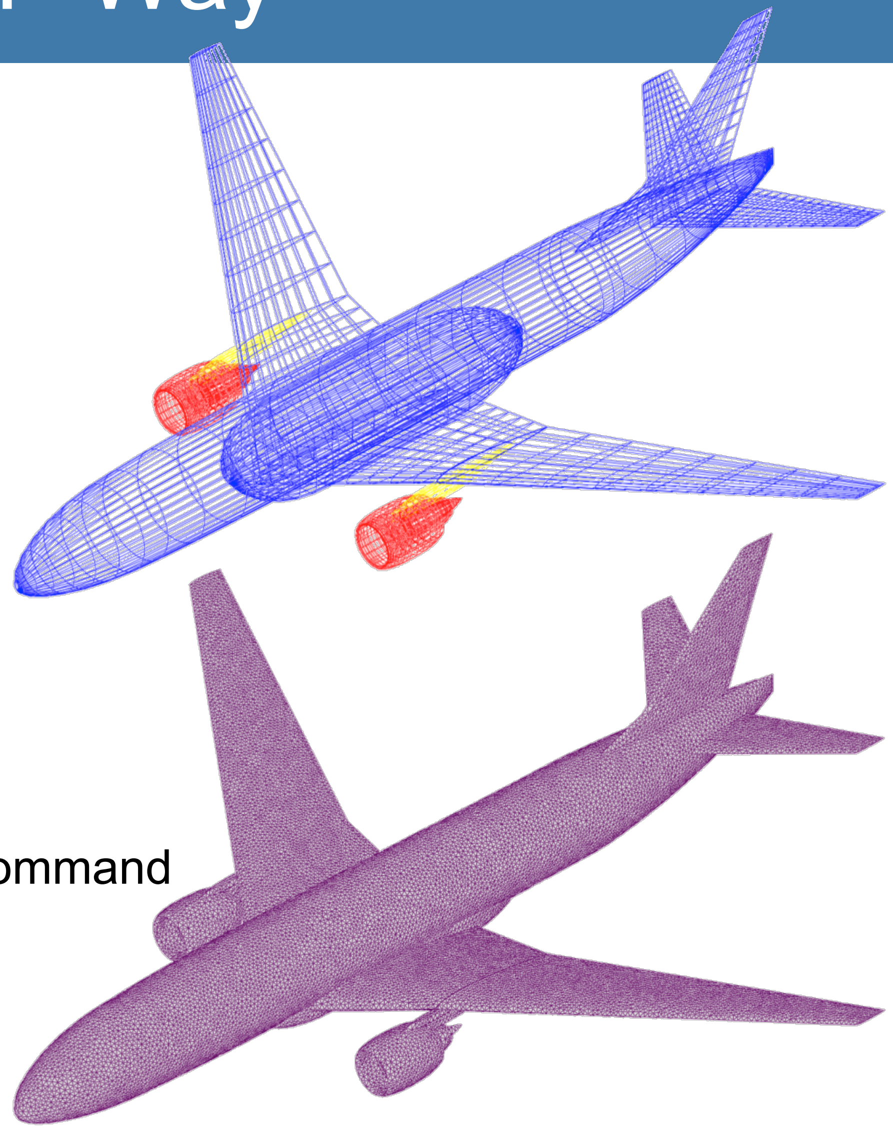
Design phase is about **what** decisions are being made,
not **how** they are made.

Vehicle Sketch Pad (VSP)

- Rapid parametric geometry for design
- NASA developed & trusted tool
  - JR Gloudemans – Primary developer
- 2010 NASA Software of the Year Honorable Mention
- Released as Open Source Software (NOSA 1.3) January 2012
- Guidelines for improvement
  - Enable improved physics-based analysis
  - Support design and optimization
  - Maintain simplicity & “The VSP Way”

“The VSP Way”

- Intuitive, Quick, Easy
  - First time users ‘instantly’ productive
- Parametric geometry for design
  - Familiar to Aerospace & Designers
    - Wings, Fuselage, Nacelle
    - AR, Sweep, b, t/c, etc.
- Real-time interactive response
  - Sliders vary parameters
  - Geometry updates interactively
- Geometry represented by cartoon
  - Not *actual* wetted surface
  - Actual wetted surface generated on command



Agenda & Questions?

	8/23 Tuesday		8/24 Wednesday		8/25 Thursday	
8:00 8:30	Welcome & Overview	Rob McDonald	Automated FEM	Wu Li	Wave Drag	Rob/Michael
8:30 9:00	Intro to OpenVSP	Brandon Litherland	Structural Modeling and OpenVSP	Trevor Laughlin	Drag buildup	Bryan Schmidt
9:00 9:30	Basic modeling	Brandon Litherland	TOW Steered Wing Structure Design	Mike Hensen	Aerodatabases with GoCart & Cart3D	Aerion
9:30 10:00	Tour of main components	Brandon Litherland	OpenVSP Inertia Calculation	Mark McMillin	Aerodatabases with GoCart & Cart3D	Aerion
10:00 10:30	Break		Break		Break	
10:30 11:00	Cal Poly NRA Final Review	Rob McDonald	RapidFEM & PBWeight	Tyler Winter	Projected Area	Rob McDonald
11:00 11:30	XSecs in detail	Brandon Litherland	VSPAERO Background	Dave Kinney	NDARC Integration	Travis Perry
11:30 12:00	USAF SBIR Report	Ben Schiltgen	VSPAERO GUI VLM Basics	Nick Brake	Aircraft design framework	Alessandro Silva
12:00 12:30						
12:30 13:00	Lunch		Lunch		Lunch	
13:00 13:30	NASA SBIR Report	Nick Brake	VSPAERO GUI VLM Advanced	Nick Brake	CompGeom and Meshing tutorial	Rob McDonald
13:30 14:00	Attach, symmetry, sets, subsurfaces	Rob McDonald	VSPAERO GUI Panel Method	Nick Brake	Flightstream	Roy Hartfield
14:00 14:30	Skinning explained	Rob McDonald	VSPAERO Test and Verification	Dave Kinney	Flightstream	Roy Hartfield
14:30 15:00	Break		Break		Break	
15:00 15:30	Advanced Wing Modeling	Rob McDonald	VSPAERO Next Steps	Dave Kinney	Design vars & xddm, API, Scripting	Rob McDonald
15:30 16:00	Conformal Components	J.R. Gloudemans	VSPAERO SUGAR braced wing aero	Doug Wells	Automation	Rob McDonald
16:00 16:30	Saved Parameter Settings	Bryan Schmidt	Advanced Parameter Linking	Rob McDonald	Fit Model Presentation	Rob McDonald
16:30 17:00	Modeling Demo	Rob McDonald	Leveraging DegenGeom	Erik Olson	Fit Model Interactive	Rob McDonald
17:00 17:30	Modeling Demo	Rob McDonald	Custom Components	Rob McDonald	Feedback session	
17:30 18:00						
18:00 18:30	BBQ social					